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COSTS OF HAULING AND LAND SPREADING OF DOMESTIC SEWAGE TREATMENT PLANT SLUDGE

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by

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Program Element 1BB043

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

One method of recycling organic wastes is land spreading of sludge from domestic sewage treatment plants. This report presents estimates of costs associated with that process.

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ABSTRACT

Estimates of capital and operating costs and operating labor man hours associated with hauling and spreading both liquid and dewatered sludge are presented. These costs are used to develop total costs for land disposal of liquid sludge for various hauling distances.

COSTS OF HAULING AND LAND SPREADING OF DOMESTIC SEWAGE TREATMENT PLANT SLUDGE

To better estimate the applicability of hauling sludge in truck and trailer tanks, the Advanced Waste Treatment Research Laboratory of the National Environmental Research Center in Cincinnati, Ohio, U.S. Environmental Protection Agency (EPA) initiated this cost finding project.

LIQUID SLUDGE

Land disposal of wet sewage sludge my be economically attractive under some conditions. Sludge may be transported from the treatment plant to the disposal area by one or more of several methods including pipeline, barge, tank truck, and railroad. This report concerns the costs associated with hauling sludge in truck and trailer tanks. This method, although more costly than some of the others, is by far the most common since it is flexible and applicable to more situations. Another advantage enjoyed by this method is that the hauling vehicle may also be used to spread the sludge at the disposal site.

Disposal Site Constraints

The nature of the disposal sites imposes many constraints on the sludge disposal process, and most of these affect operating costs. If the land is under the control of the same agency that operates the wastewater treatment plant, availability of the site will be ensured even though operations still depend on the weather. This is especially true when spreading is done by driving the hauling vehicle off the road and onto the land. If private owners control the land, it will be less available because such land will usually be in use in some agricultural activity. This, in turn, means that there must be sufficient hauling capacity to move the sludge out of the plant during the available working days.

Truck Size Constraints

Road laws in the various states impose upper limits on tank capacities. If the hauling vehicle is also used to distribute the sludge, there will be other practical limits on size depending on the terrain over which the vehicle will be driven. If the vehicle is only to be driven on the highways, the maximum capacity, under Ohio road laws, for example, will be about 5800 gallons when carried in a five-axle, tractor, semi-trailer combination. Although Montgomery County, Ohio, uses such a vehicle, (with about a 5000-gallon capacity) to spread as well as haul sludge, using truck-mounted tanks for sludge spreading is much more common.

The upper size limit for truck tanks in Ohio, for example, is about 2500 gallons for a three-axle truck. However, some wastewater treatment plants use trucks of this type, with only a fraction of the legal loads, to provide better flotation over soft ground. The most commonly used truck is, of course, the two-axle type. About 1200 gallons of sludge would seem to be a reasonable average capacity, although this may be lower than the legal limit on Ohio roads.

Cost Data Sources

Reported, estimated, and experienced costs (1-5), as well as those presented in annual reports from various treatment plants, vary widely and range from about $.50 to $2.00 per mile for round trip distances of under 20 miles. Inquiries made of several treatment plant managers not only disclosed local conditions that accounted for some of the differences in costs but also suggested that meager cost records and inconsistent reporting were, in some instances, responsible for some of this cost spread.

In order to compare these reported sludge hauling costs with comparable costs incurred in private industry and other government agencies, the following sources were contacted: local representatives of truck and tank manufacturers, the General Services

Administration, local common carriers, the Office of Solid Waste Management Programs of EPA, and a major oil company. This oil company uses a large fleet of tank vehicles in both short-haul, one-way operations and over-the-road trucking of gasoline and fuel oil on longer one-way hauls. Automotive equipment prices were obtained only from manufacturer's representatives. The other sources, named above, supplied operating and maintenance costs.

Cost Calculations

Capital costs (Figure 1) are expressed as a function of payload, in gallons, for both tank trucks and semi-trailer tank trucks. The estimates, obtained from equipment manufacturers, apply to diesel powered units in all except the smallest sizes. A proportionate share of the treatment plant yard work cost is also included together with a 20% allowance for engineering, legal, fiscal, and administrative costs.

For the usual tratment plant facilities, a period of 25 years has commonly been used as the basis for computing amortization costs. However, this is much too long a time for automotive vehicles. The U.S. Internal Revenue Service allows 6 years for depreciation of heavy trucks used in private industry (5); that figure is used in this study.

Operating and maintenance costs (Figure 2) are made up of charges for preventive and repair maintenance work on the vehicles, fuel costs, driver's wages, and amortization costs. An allowance for indirect labor, supervision, and general expenses, equal to 25% of the direct cost is also included. The truck drivers were assumed to be sewage treatment plant employees earning an average wage of $3.97 per hour.

Hauling and Spreading

Since it is desirable to express costs in cents per mile, assumptions were made with respect to the hauling distance and the

number of days per year when it would be possible to drive onto the spreading site. The operation and maintenance costs (Figure 2) are based on the assumptions that round trip hauling distances will range from 10 to 60 miles (16 to 96 Km) and that land spreading will be carried out on 195 days (9 months) each year. Average road speeds were taken to be 25 miles per hour, (40 Km/h) and loading and unloading times were assumed to be 15 minutes each. Another assumption was that the truck driver would be assigned to other tasks at the treatment plant on those days when he was not engaged in hauling sludge and that the time devoted to such other work would not be charged to sludge hauling.

The cost of operating and maintaining a semi-trailer that would be used to haul sludge to a fixed discharge facility, such as a holding pond, is shown as a single point on Figure 2. It was assumed that such a vehicle could operate in any weather and would be in use 5 days each week throughout the year. Round trip distance for this operation was assumed to be 260 (416 Km) miles with an average road speed of 35 (56 Km/h) miles per hour. Loading and unloading times were again assumed to be 15 minutes each.

Trips Per Day

The number of trips that a vehicle could make in an 8-hour day, based on the above assumed average speeds and loading times, are shown to aid in selecting the proper cost curve for a particular application.

Sludge Hauling and Spreading

Round Trip Distance, miles	10	20	30	40	60
Trips Per Day	8	6	4	3	2

Point-to-Point Sludge Hauling

Round Trip Distance, miles	260
Trips Per Day	1

DEWATERED SLUDGE

One possible alternative to hauling and spreading liquid sludge by tank vehicles is to dewater the sludge by some means such as vacuum filters or sand drying beds and then haul it to the disposal site in dump trucks or trailers. Hauling costs are less for this method since less water is carried. Because dump trucks and trailers are not suitable for land spreading this material, cost of another operation, spreading, will be incurred at the disposal site. The method used to load the trucks will depend on the dewatering method: a belt conveyor to carry sludge from a vacuum filter or a belt loader or front loader, from sand drying beds. In either case, the cost of loading equipment and the labor to operate it are associated with the dewatering facility and are not included here.

Subsequent Land Spreading

It is assumed that the dewatered sludge will be simply dumped from the hauling vehicles at the disposal site and that it will be subsequently spread with some type of equipment such as manure spreaders, scrapers, or graders. Although the cost of this spreading should be included, if the total costs of hauling and spreading liquid and dewatered sludge are compared, capital and operating costs for spreading are not included here. Rather, the cost of land spreading of dewatered sludge may be roughly estimated at $1.00 per ton of sludge.

Truck Size Constraints

Since the hauling vehicles are not required to drive over the land at the disposal site, year-round hauling is feasible and trucks may be loaded to the maximum legal weight limits. Maximum loads will depend on state road laws. In Ohio, for example, the maximum pay load that could be hauled in a five-axle tractor, semi-trailer combination would be about 22 tons. For a three-axle truck, the maximum would be about 10 tons; for a two-axle truck, about 7½ tons.

Costs

Capital costs (Figure 3) are expressed as a function of payload, in tons, for trucks and semi-trailer rigs with dump bodies. These estimates come from equipment manufacturers and apply to diesel powered units for all sizes. A proportionate share of the treatment-plant yard work cost is included. Debt service cost is again based on a 6-year life and 6 percent interest.

Operating and maintenance costs (Figure 4) were estimated in the same manner as those for hauling liquid sludge except that it was assumed that these vehicles would be in use 40 hours per week for 52 weeks per year. An allowance of 25 percent of the direct costs is included for indirect labor, supervision, and general expenses.

Alternate Method of Cost Presentation

In the preceeding sections of this report, the capital costs included a proportionate share of the costs of treatment-plant yard work, and the operating and maintenance costs included an allowance for indirect labor, supervision, and general expense. This is appropriate if the hauling and spreading of sludge is to be considered as a process apart from the remainder of the treatment plant. However, if these costs are to be added to the costs of other unit processes described elsewhere (6, 7) it is essential that they be expressed differently and be related to appropriate process sizing parameters. Figures 5 through 8 reflect this system of cost calculation.

Liquid Sludge

Figure 5 presents capital costs for the hauling vehicles only, with no allowance for yard work.

Figure 6 shows operating labor requirements in terms of payroll man hours per mile per thousand gallons of sludge hauled. This

labor includes only the driver with no allowance for indirect or administrative labor. Labor required for preventive and repair maintenance of the vehicles is relatively small, often done at non-plant truck service facilities, and is included under maintenance costs shown below.

The operating and maintenance costs per mile, exclusive of amortization and driver's wages, are affected very little by the total number of miles driven per year and, within the limits assumed for this study (15,000 to 25,000 miles per year), (24,000 to 40,000 Km per year) they may be assumed constant for a given vehicle size. These costs were estimated to be:

Semi-trailer, 5500 gal.....40¢ per mi. (25¢/Km)
Large truck, 2500 gal.....35¢ per mi. (22¢/Km)
Small truck, 1200 gal.....23¢ per mi. (14¢/Km)

For point-to-point hauling, with a 5500-gallon semi-trailer driven from 70,000 to 100,000 miles per year, the average operating and maintenance cost would be about 30 cents per mile. (19 cents per Km)

Dewatered Sludge

Figure 7 shows the capital cost for the hauling vehicles with no allowance for yard work. Figure 8 shows operating labor requirements in terms of payroll man hours per ton mile as a function of hauling distance. As with liquid sludge, this labor includes only the driver. The labor required for preventive and repair maintenance is again included in maintenance costs, which may be assumed to be constant for a given vehicle size. These costs, shown below, give the vehicle size in tons and do not include amortization or drivers' wages.

Semi-trailer, 22 tons.....40¢ mi.
Three-axle truck, 10 tons.....35¢ mi.
Two-axle truck, 7½ tons.....23¢ mi.

Total Cost of Liquid Sludge Disposal by Land Spreading

To illustrate the application of the foregoing hauling and spreading costs, the capital costs (Figure 5) and manpower requirements (Figure 6) were used as inputs into our Executive Digital Computer Program (7) to calculate the total costs of liquid sludge disposal on land. These costs, which are expressed in terms of dollars per ton of dry solids, are presented for three sizes of activated sludge sewage treatment plants; (1, 10 and 100 mgd capacity) (3,785, 37,850 and 378,500 M^3/day) and for three sizes of hauling vehicles (Figures 9 and 10).

Disposal costs include the cost of sludge storage lagoons, the cost of sludge hauling, and interest charges based on the price of land on which the sludge is spread. It was assumed that 1630 gallon of wet sludge would be produced per million gallons of sewage treated (1630 M^3 per 1,000,000 M^3) and that sludge would be applied at a rate equivalent to 15 tons of dry solids per year per acre (33.7 t per ha). The storage period, before spreading, was assumed to be 0.25 years. No excess capacity was provided.

Capital cost of the lagoons was amortized at 6 percent for 25 years. The land on which the sludge is spread was assumed to have a constant value of $1000 per acre for the purpose of calculating an interest expense at 6 percent per annum. Hauling vehicles were amortized at 6 percent for 6 years. Plant size, vehicle size, hauling distance, and sludge concentration were varied to obtain the curves shown in Figures 9 and 10.

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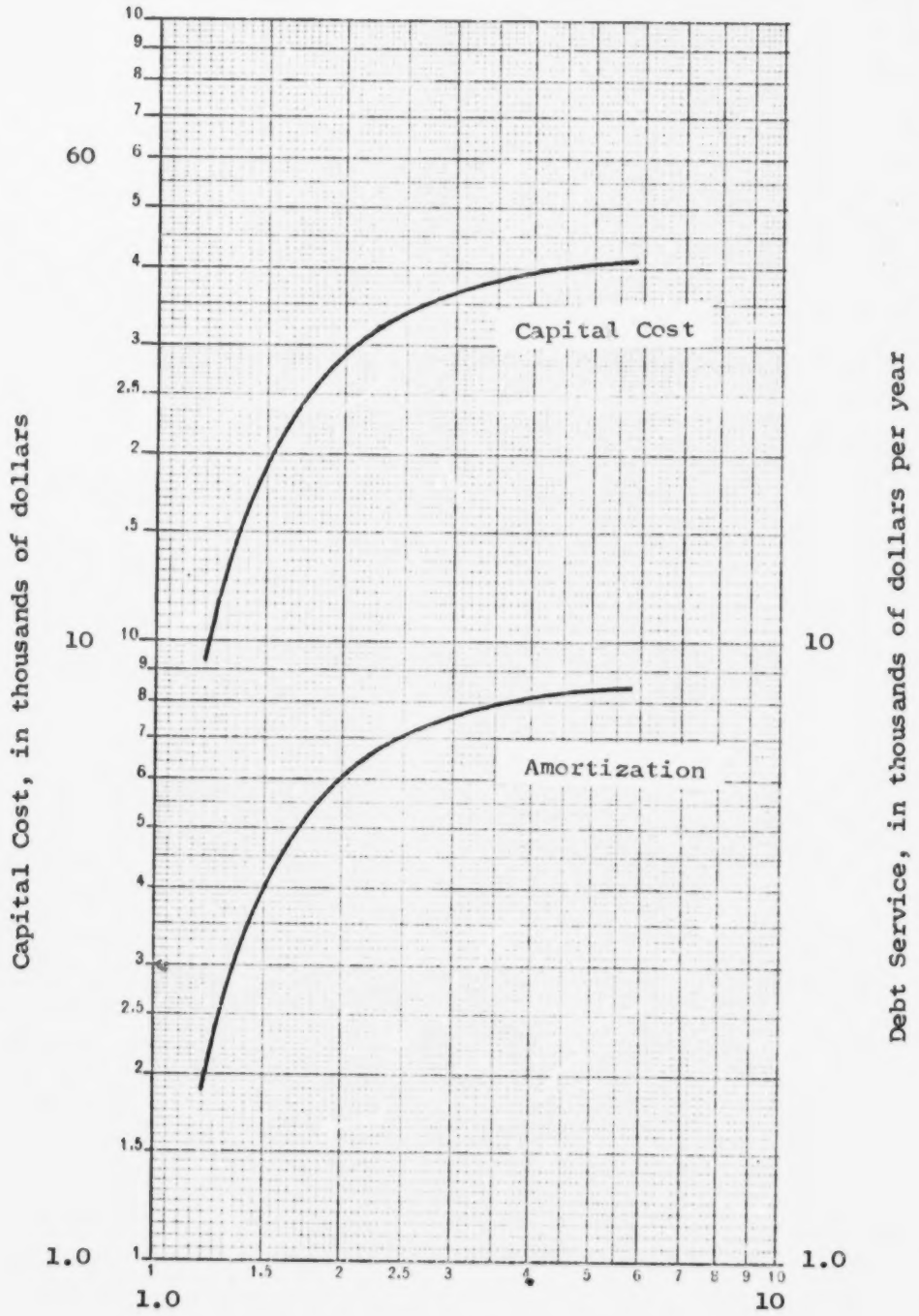

Figure 1

Capital cost and amortization of tank vehicles for sludge hauling versus payload.

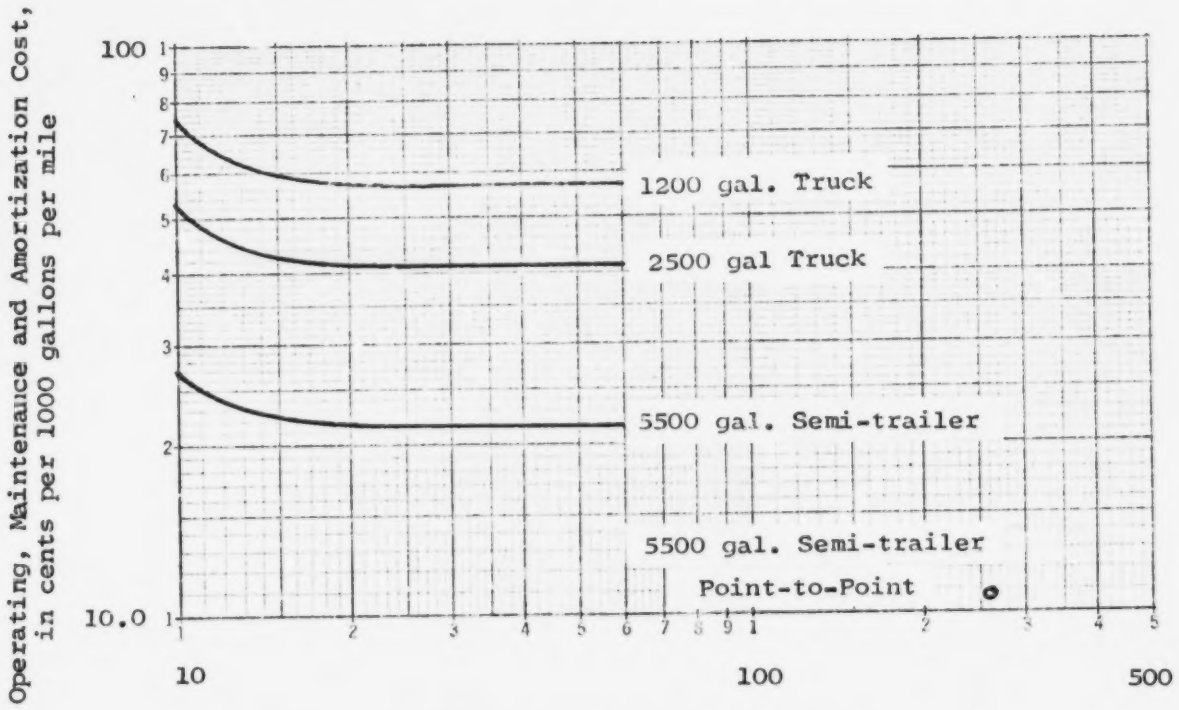

Figure 2

Operating, maintenance, and amortization cost of tank vehicles for sludge hauling versus hauling distance.

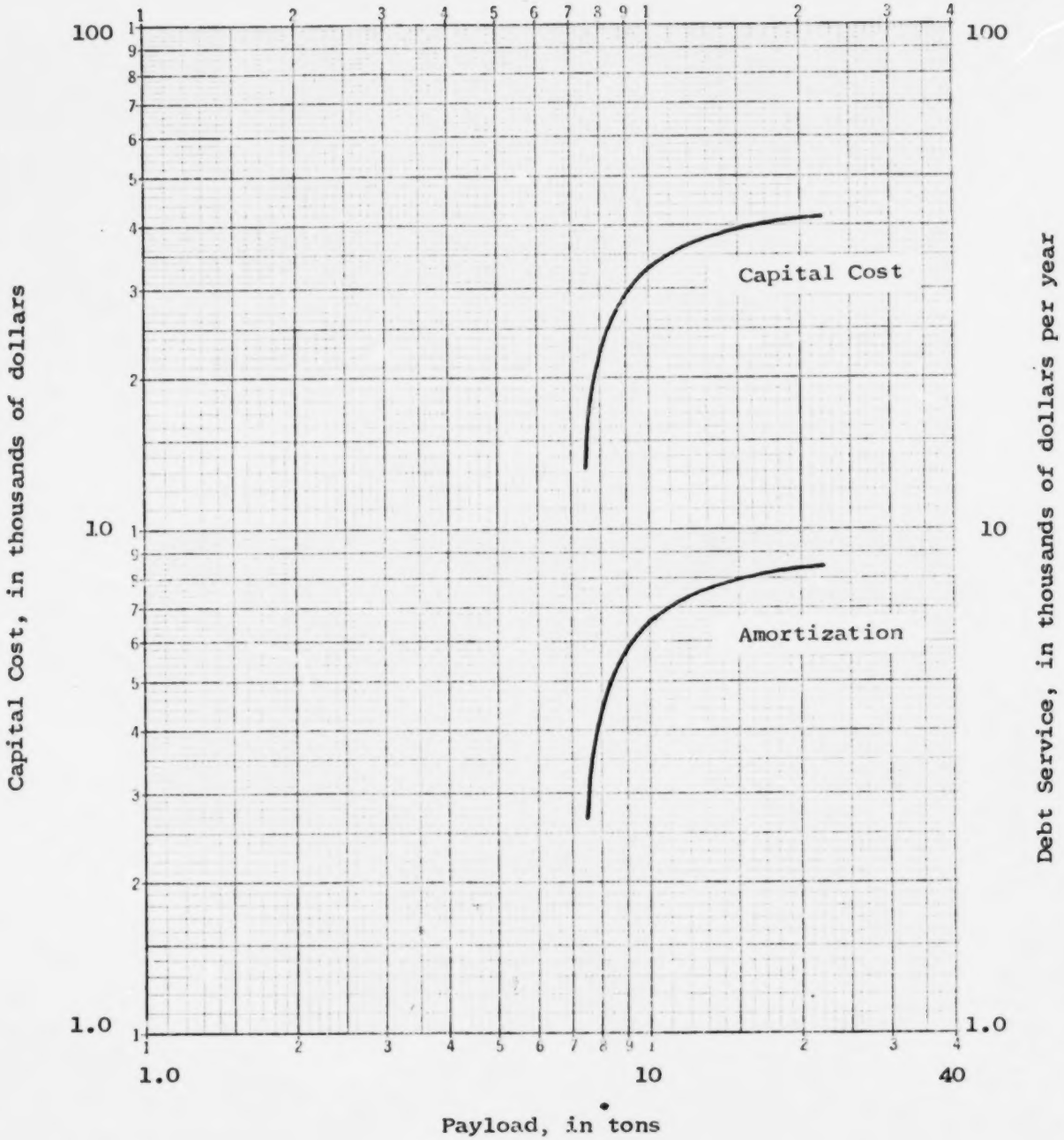

Figure 3

Capital cost and amortization of dump body vehicles for sludge hauling versus payload.

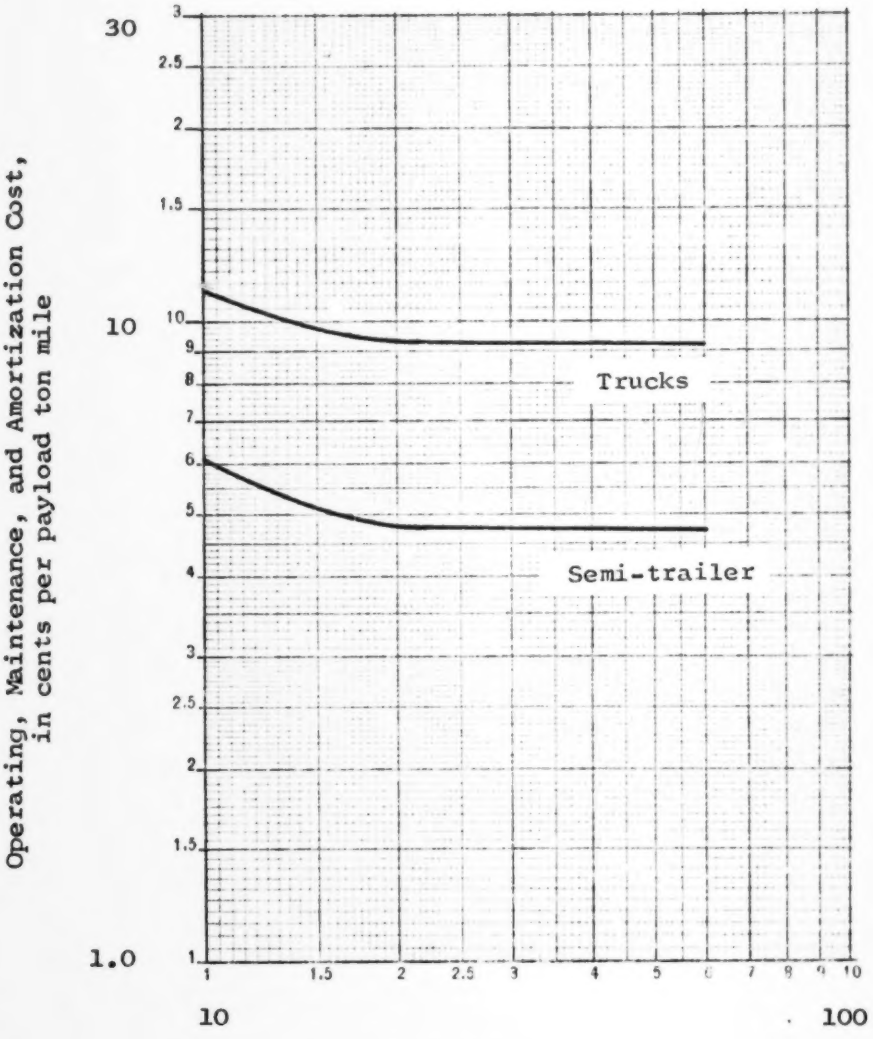

Figure 4

Operating, maintenance, and amortization costs of dump body vehicles for sludge hauling versus hauling distance.

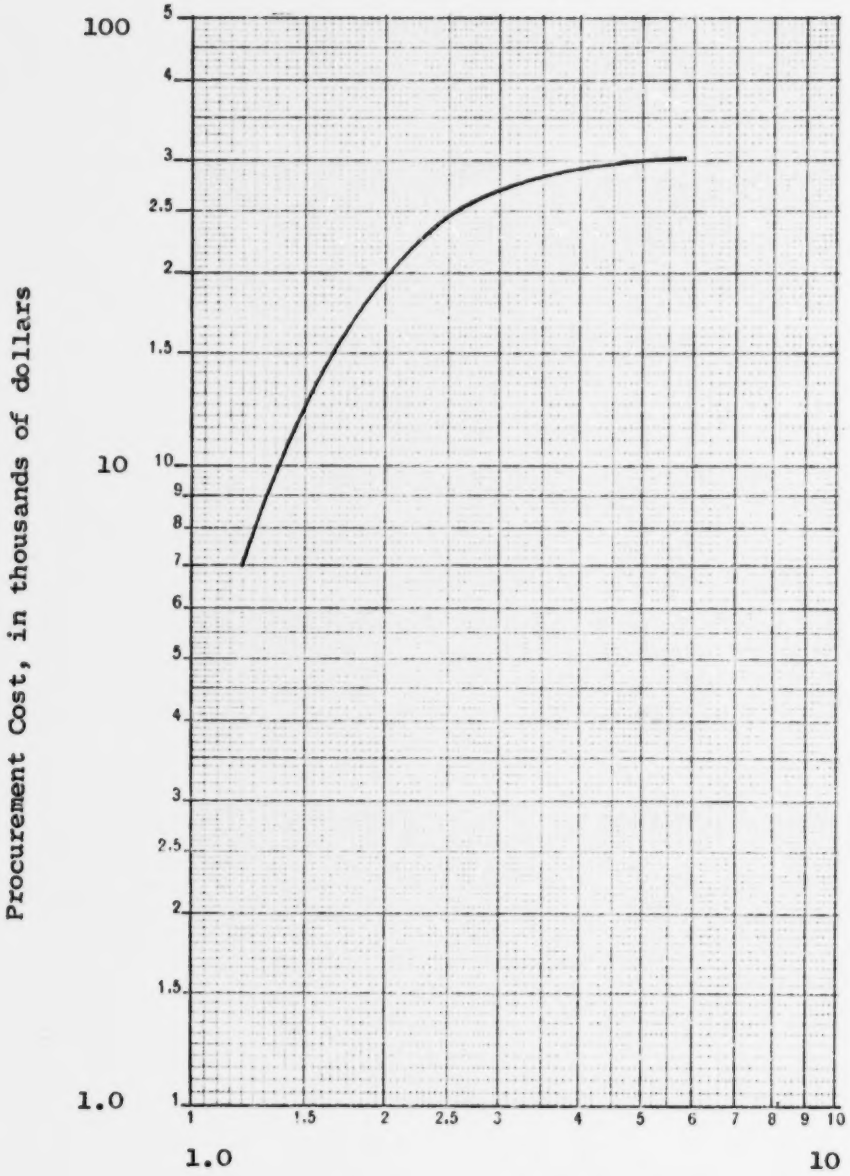

Figure 5

Procurement cost of tank vehicles for sludge hauling versus payload.

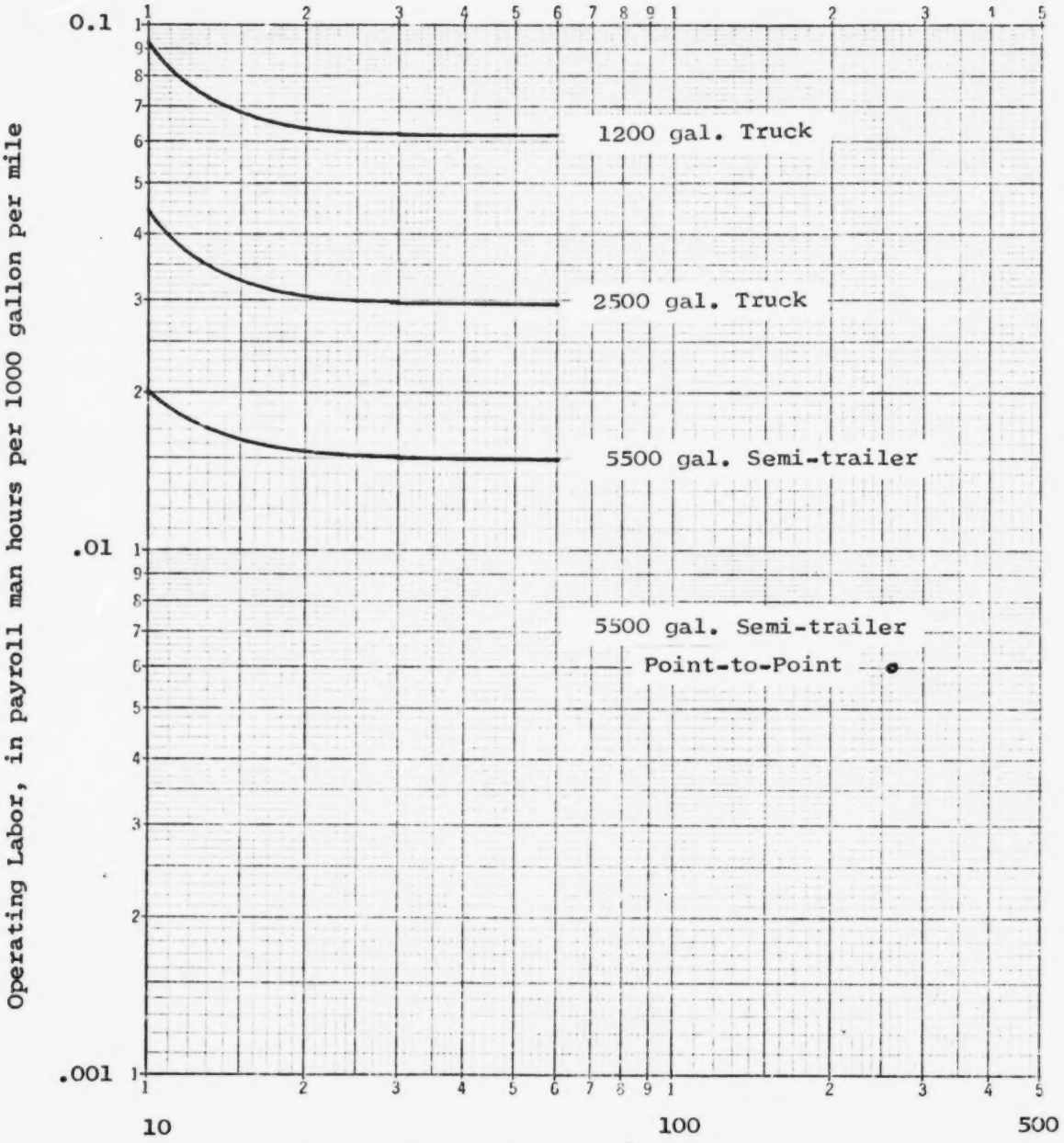

Figure 6

Operating manpower for liquid sludge hauling and spreading versus hauling distance.

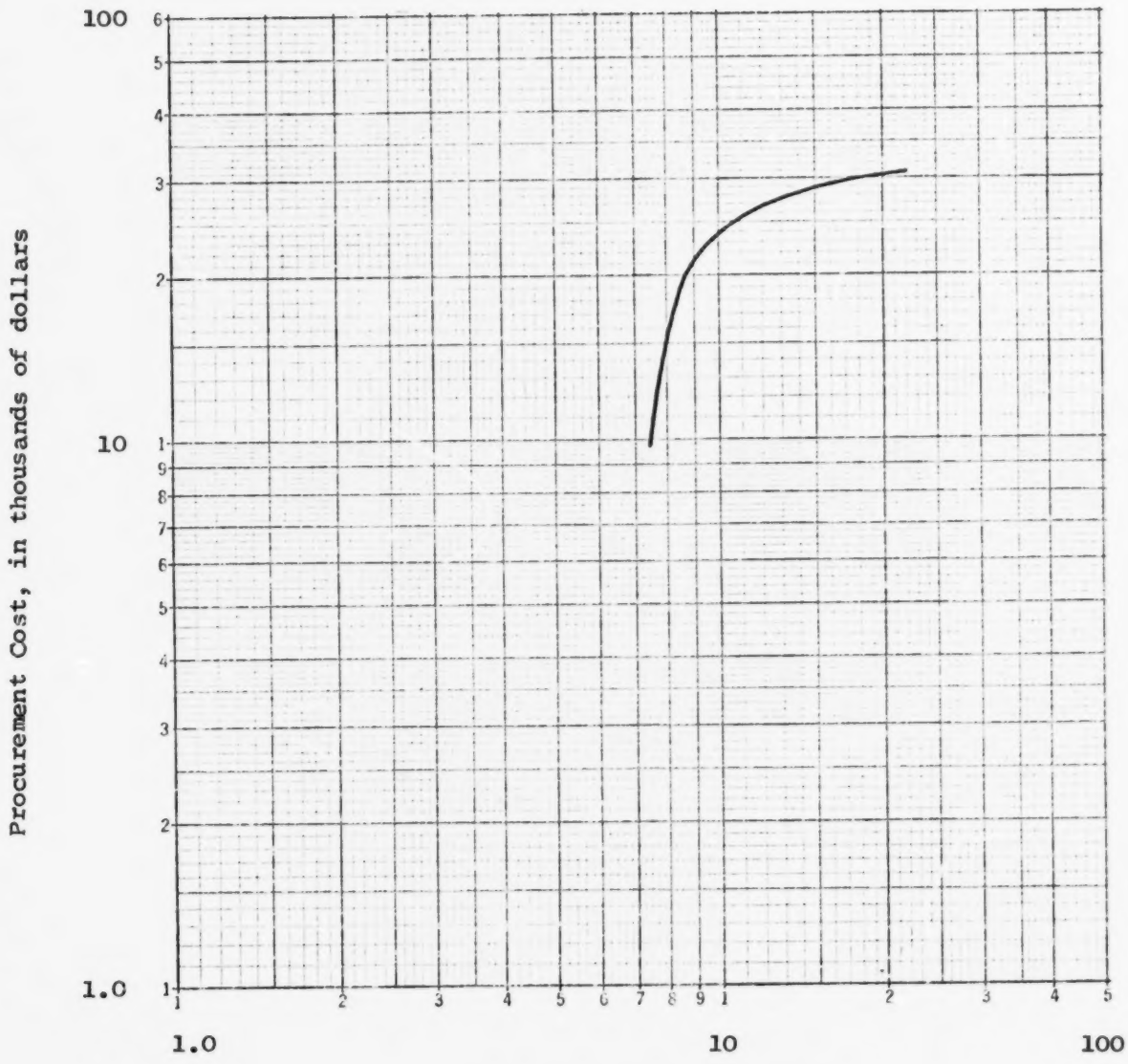

Figure 7

Procurement cost of dump body vehicles for sludge hauling versus payload.

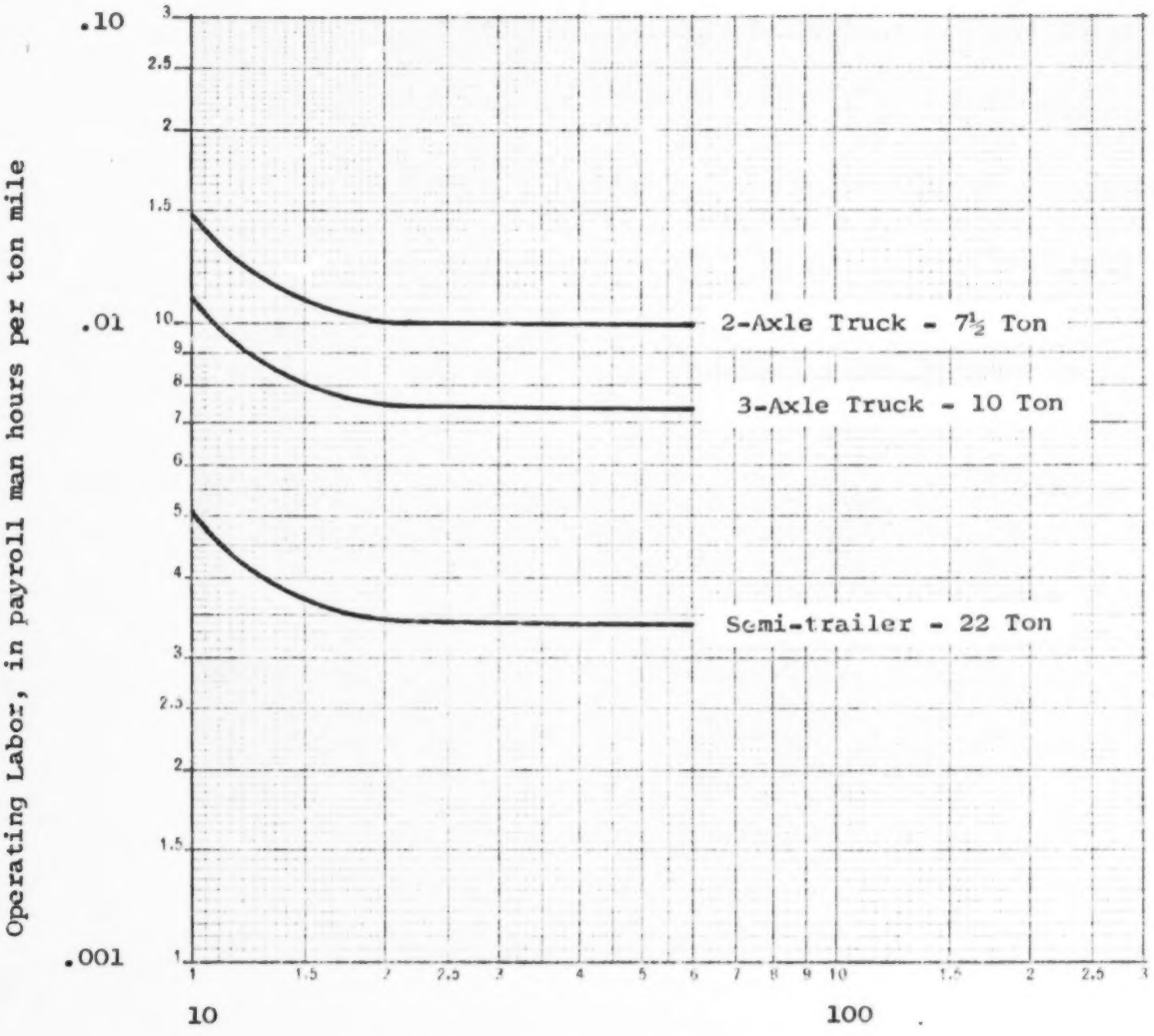

Figure 8

Operating manpower for dewatered sludge hauling versus hauling distance.

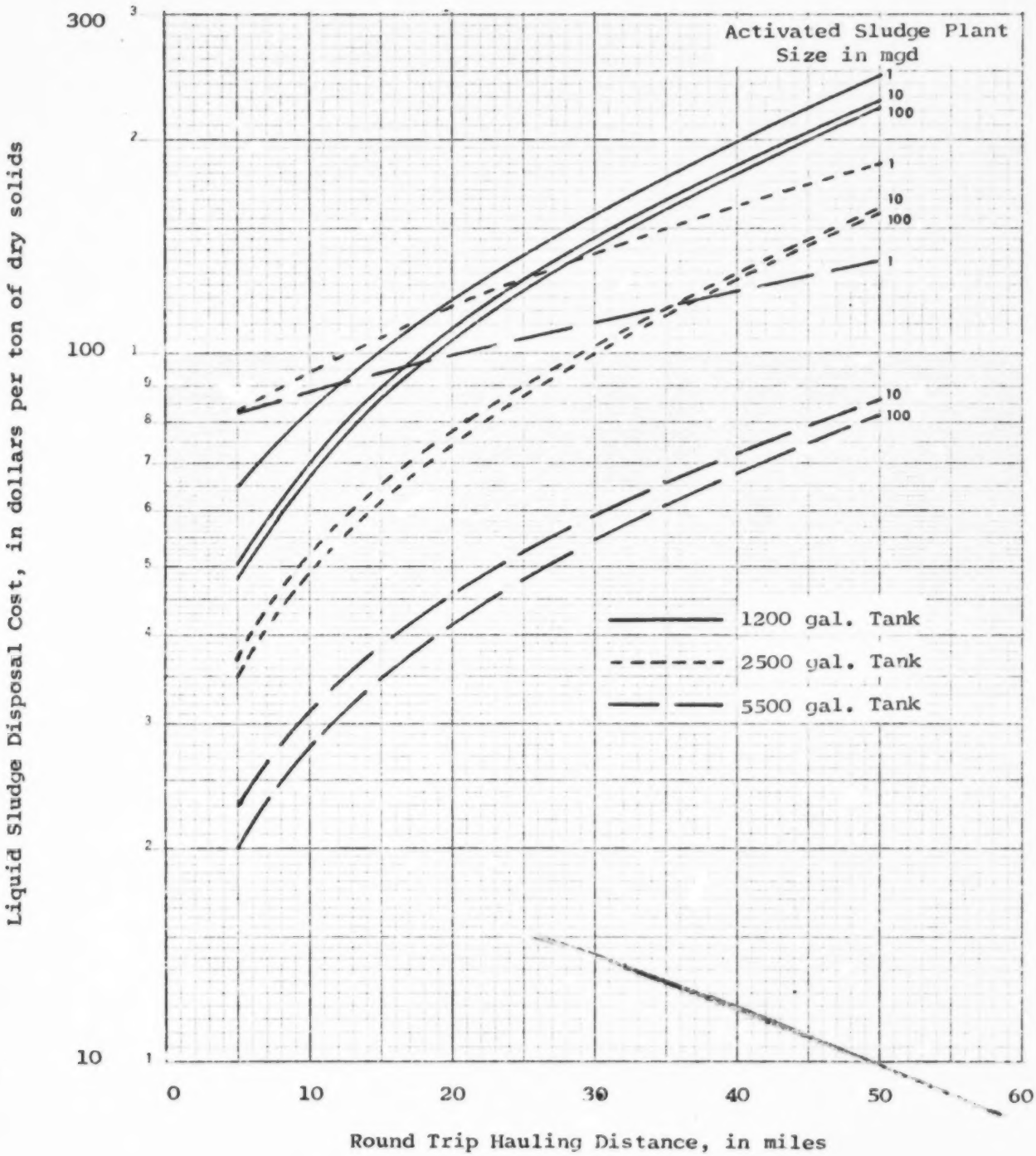

Figure 9

Cost of liquid sludge disposal by land spreading versus hauling distance for 2½% sludge solids concentration. (Includes the costs of land for spreading, storage lagoons and hauling)

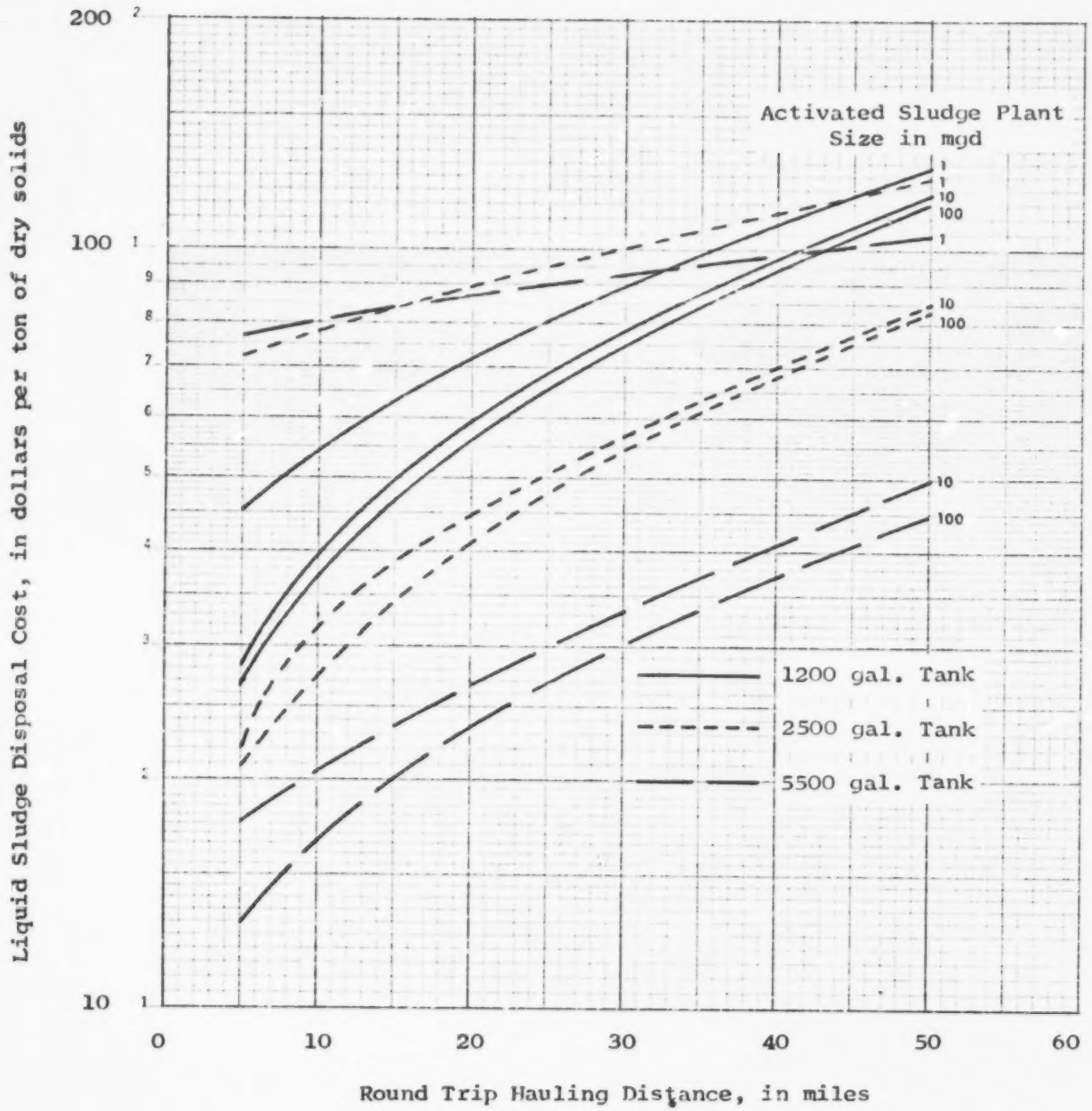

Figure 10

Cost of liquid sludge disposal by land spreading versus hauling distance for 5% sludge solids concentration. (Includes the costs of land for spreading, storage lagoons and hauling)